SECTION 550.00 – SUBSURFACE PAVEMENT DRAINAGE

550.01 General. Interstate Highways and all other highways with 1,000 or more truck ADT shall incorporate a Positive Drainage System for new or reconstructed Asphalt Concrete and Portland Cement Concrete Pavement.

On highways with less than 1,000 truck ADT, subsurface drainage shall be addressed on a project by project basis. Such things as rainfall, groundwater, subgrade type, topography and drainage areas shall be considered. Research indicates that about 40% of the moisture that falls on the roadway finds its way into the drains.

Positive drainage discharge shall be incorporated as part of the subsurface drainage system.

The value of retrofit edgedrains depends on the pavement type and condition, base type and permeability, subgrade conditions, climate and type of distress evident. Therefore, their use will be addressed on a case-by-case basis. Where retrofit edgedrains are recommended, design shall be in accordance with applicable portions of this section.

A preliminary permeable base design shall be included in the Phase I Materials Report.

550.02 Selecting Permeable Bases. The purpose of the permeable base is to remove all the gravity drainable water from the pavement structure. The construction and performance of permeable bases will depend on the type of material, gradation, layer treatment, separation layer, pavement cross slope, shoulder material and edgedrain system. The permeable base must provide four very important functions:

- Must be permeable enough and thick enough to allow 50% of the free water to drain within the design time period. Recommended design time periods are 2 hours for interstate pavements and 2 to 5 hours for non-interstate pavements.
- Must provide enough stability to support the pavement construction operation.
- Must have enough stability to provide the necessary structural support for the pavement structure.
- Must have sufficient hydraulic gradient in the desired flow path.

Permeable base material shall consist of durable, crushed, angular aggregate.

550.03 Unstabilized Permeable Base (Rock Cap). When rock cap is chosen for the permeable base, an extensive analysis is not necessary.

The rock cap should consist of 100% open graded crushed stone and the maximum LA abrasion should not exceed 45%.

The minimum layer thickness should be not less than 300 cm (1.0'), unless placed on existing pavement in which case the minimum thickness shall be 180 mm (0.6'). The minimum thickness is based on particle size and geotextile protection rather than permeability.

Rock cap is assigned a structural equivalent of 1.2:1, with respect to crushed aggregate base.

A geotextile shall be placed between the subgrade and the rock cap as needed.

A 45 mm (0.15') thick binder course of asphalt pavement or permeable asphalt pavement should be placed on top the rock cap to facilitate the paving operation. If the pavement is to be concrete, the binder course shall be an asphalt treated permeable leveling course (ATPLC).

Partial longitudinal drains, i.e., 15 m at 90.0 to 150.0 m (50' at 300' to 500') intervals shall be used.

Additional drainage may be needed at springs, sag curves or in areas of high ground water. Cross subdrainage may be needed at grade points, sag curves, cuts experiencing artesian flow, bridge abutments, project termini and at maximum intervals of 150 m (500') on grades of 4% or steeper.

The rock cap should conform to the following gradation:

Sieve Size	% Passing
63.0 mm (2½")	100
37.5 mm (1½")	65 - 80
19.0 mm (¾")	15 - 30
12.5 mm (½")	5 - 15
2.36 mm (No. 4)	0 - 5

This gradation results in a permeability on the order of 9000 m/day (30,000 ft./day) (see Figure 550.03-1). To prevent erosion of the subgrade and/or intrusion of fines into the rockcap, a filter layer or geotextile filter/separator will be needed between the rock cap and subgrade on all but coarse sand and gravel subgrades (which meet filter criteria).

550.04 Stabilized Permeable Bases. Stabilized Permeable Base should be open-graded asphalt or cement treated aggregate with approximately 3.0% asphalt cement by weight or 5.0% portland cement by weight.

The minimum thickness of stabilized permeable base should be 90 mm (0.3'). Stabilized permeable bases should be placed over a filter consisting of at least 150 mm (0.5') of crushed aggregate base.

The aggregate should have a minimum of 90% of the particles retained on the No. 4 sieve exhibiting at least one mechanical fractured face and 60% should have at least two fractured faces.

The maximum LA abrasion should not exceed 35 and the aggregate should conform to the following gradation:

Sieve Size	% Passing
25.0 mm (1")	100
19.0 mm (¾")	90 - 100
12.5 mm (½")	35 - 65
9.5 mm (3/8")	20 - 45
4.75 mm (No. 4)	0 - 10
2.36 mm (No. 8)	0 - 5
.075 mm (No. 200)	0 - 2

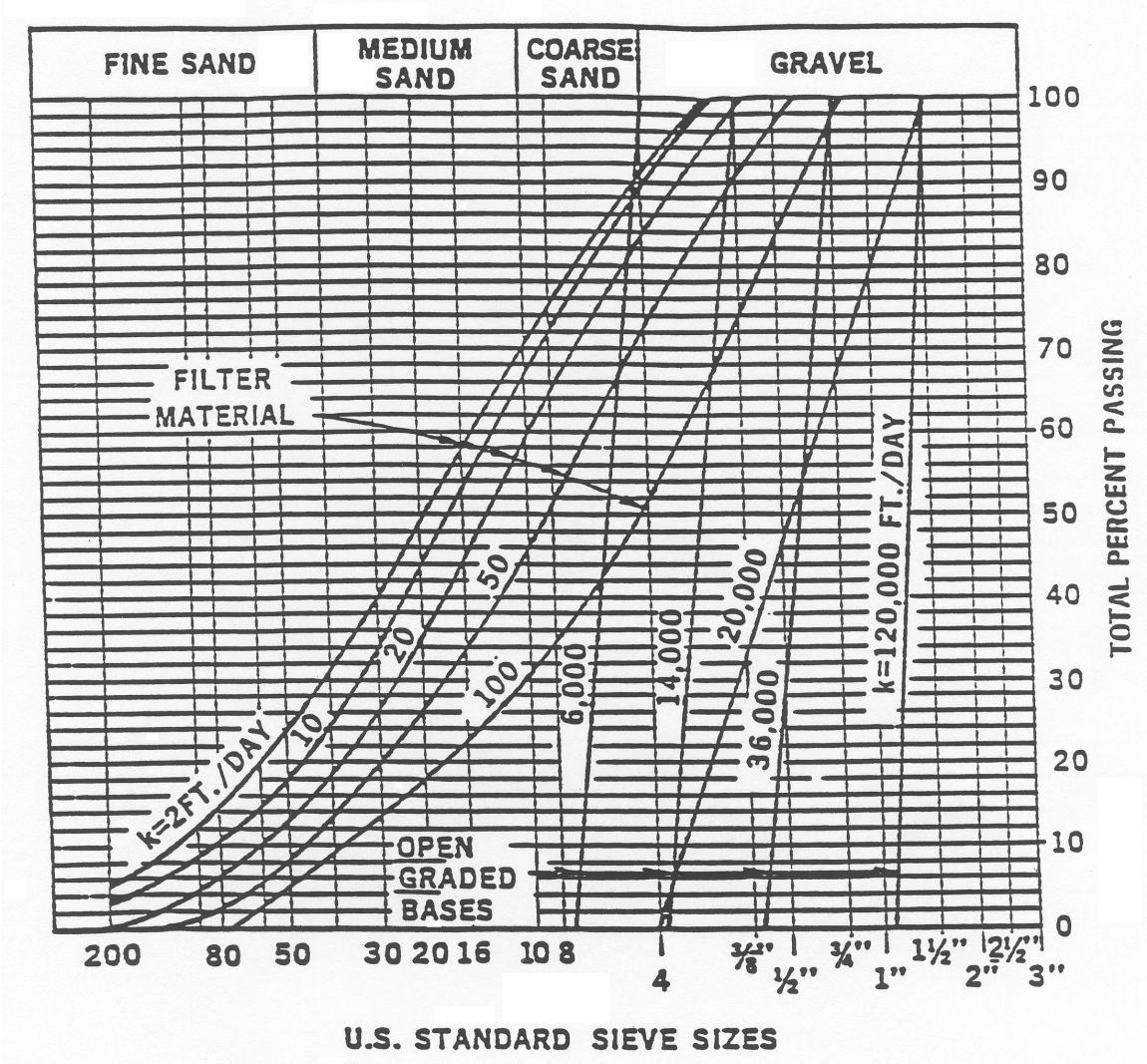

FIGURE 550.03-1

550.05 Drainage Collection System. A conventional collection system consisting of trench, slotted pipe and aggregate backfill is recommended rather than geocomposite drains because of problems inherent in proper installation, blinding of the geotextile and the build-up of fines that pass through the geotextile and settle in the core.

Edge drains should be placed from 0 to 600 mm (up to 2 ft.) outside of the edge of the pavement and the drainage layer should extend completely across the edge drain trench.

A drainage geotextile shall be used around the edge drain trench with enough excess on each side to cover the width of the trench. Prior to placing the permeable layer, the excess geotextile shall be folded so as to lay flat outside the trench on each side. This will permit direct contact between the permeable layer and the trench backfill material. Geotextiles shall conform to "SSP - 718 - GEOTEXTILES" with Standard Specifications Section 718.06 - Drainage Geotextile Property Requirements.

The edge drain trench should be a minimum of 100 mm (4 in.) below the subgrade elevation and provide for at least 50 mm (2 in.) of bedding material under the edge drain pipe.

Trench depth must be enough to accommodate the intended drainage pipe and the minimum width shall be 250 mm (10 in.).

Trench backfill material shall be clean drain aggregate such as pea gravel [12.5 mm - 4.75 mm (0.5 in - No. 4)] or coarse aggregate for concrete, Standard Specifications, Section 703.03.

The edge drain pipe must be slotted or perforated, should have a diameter of 100 mm (4 in.) to 150 mm (6 in.) and should meet the requirements of Standard Specifications, Section 706.10 - Corrugated Polyethylene Drainage Tubing or Section 706.14 - Class PS-50 Polyvinyl Chloride (PVC) Pipe.

The edge drain pipe should have a minimum grade of 0.5%. In special cases, gradients as flat as 0.2% can be used. However, silting of the pipe may be a problem and larger pipe diameters may be needed.

Where outlet pipes are close to the ground surface and may be damaged by construction or maintenance equipment (such as where outlet pipes exit the shoulder foreslope) consideration should be given to using PVC pipe or placing the outlet pipe in a sleeve, for additional protection.

Outlet pipes should be non-perforated, smooth-wall pipes at a maximum spacing based on the hydraulic capacity of the edge drain, typically 120 m (400 ft.).

Outlet pipes shall have a minimum grade of 1% with a grade of approximately 3% being desirable and should be skewed 45 degrees to the edge drains.

Outlet pipes must be located at the bottom of all sag vertical curves and these must be turned 90 degrees to the edge drains.

The pipes must be turned or skewed using large radii bends, 0.75 m to 1.0 m (2 to 3 ft.) to facilitate maintenance of the drainage system. Typically the upstream end of edge drains are brought to the surface, capped and used as clean outs.

Pipes should outlet a minimum of 150 mm (6 in.) of freeboard above the bottom of the ditch. Where this cannot be obtained, a system should be designed to collect the outlet flow and discharge it at an acceptable outfall.

Joints in all edge drain pipes and outlets should be kept to a minimum. Where joints are required, couplings are to be used.

Precast or cast-in-place concrete outlet headwalls must be used and must include removable rodent screens.

NPDES requirements should be considered when determining the locations of the drainage outlets.

Typical drainage type details are shown in the Figures 550.05-1 and 550.05-2.

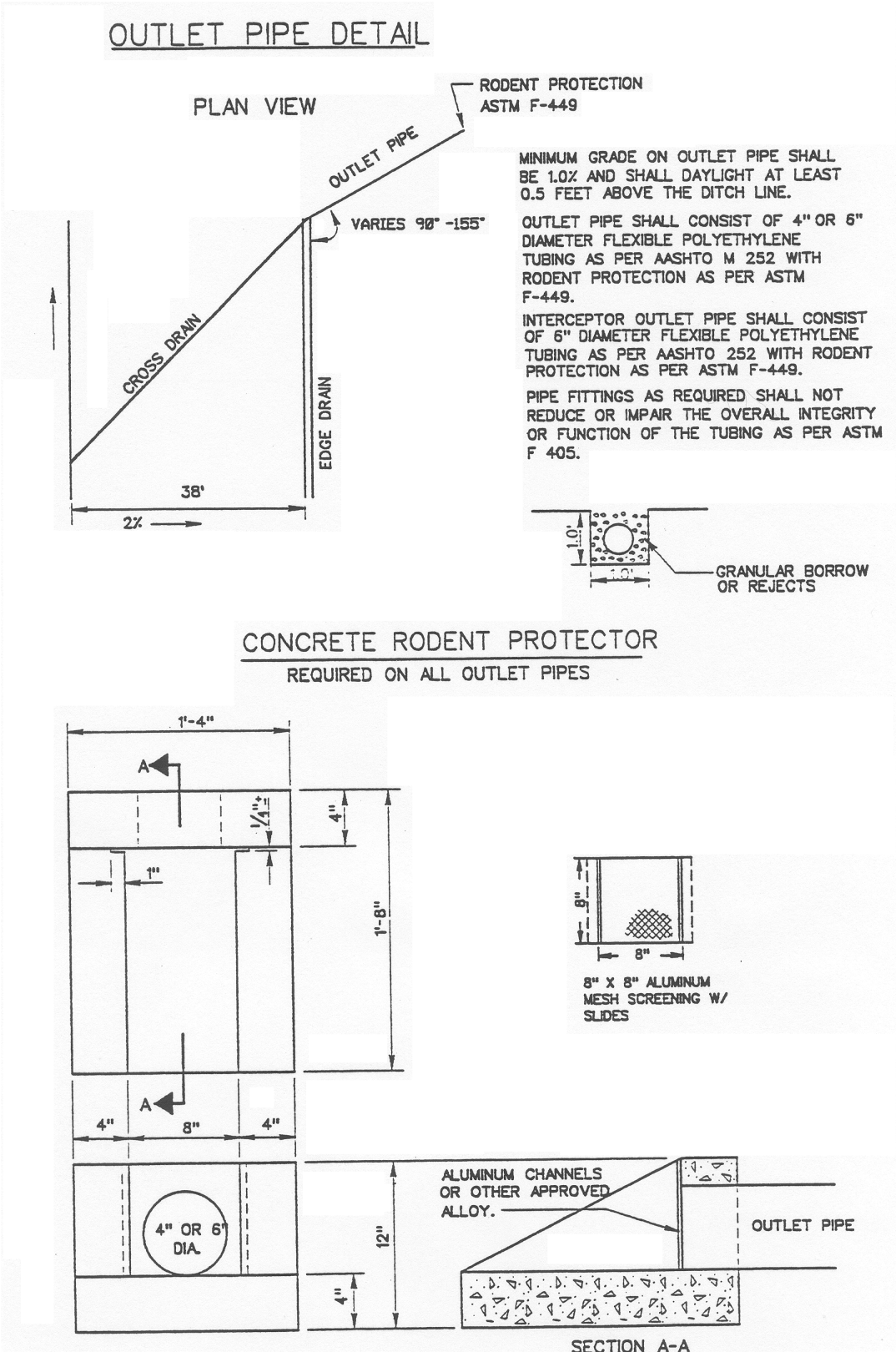

FIGURE 550.05-1

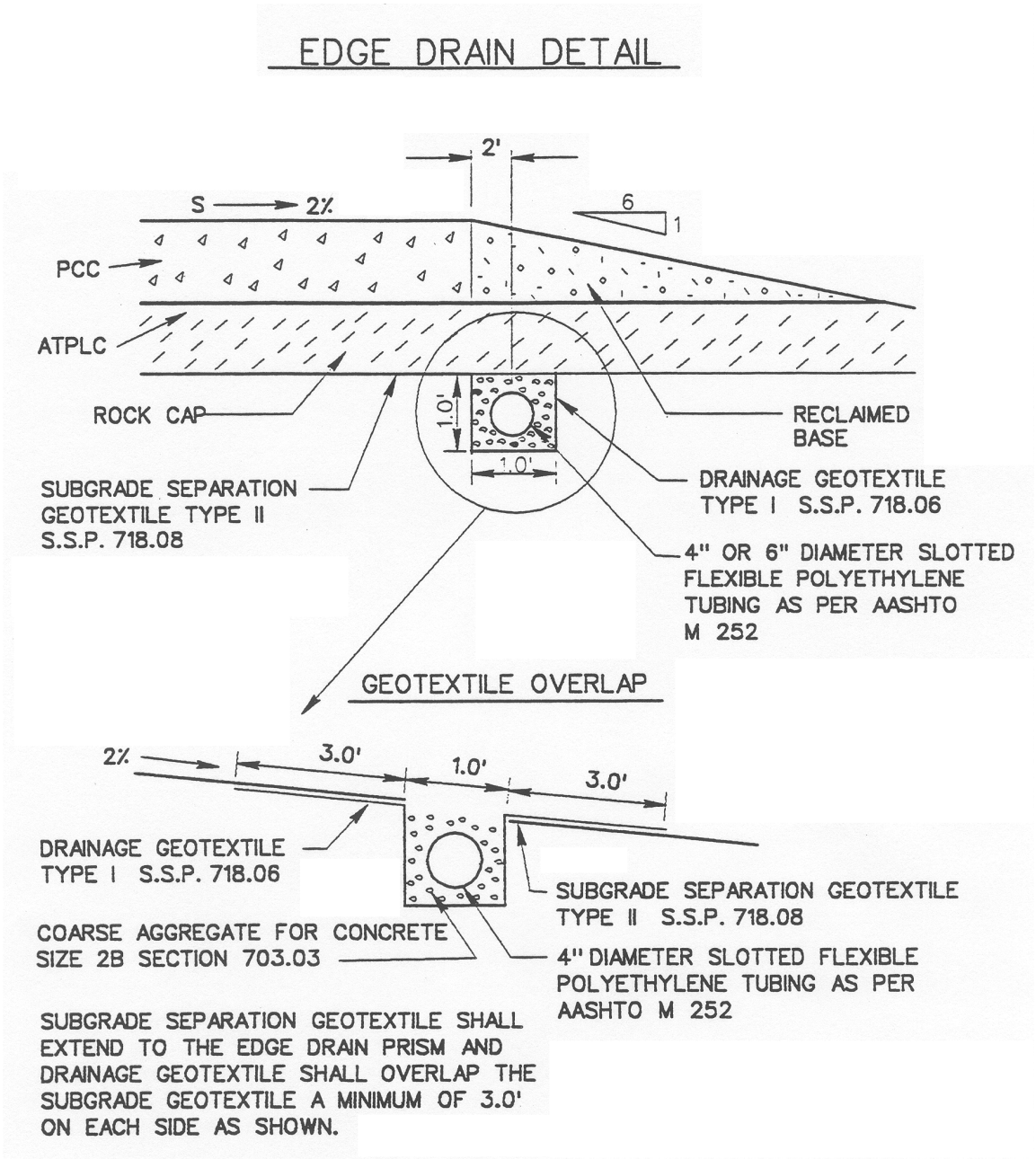

FIGURE 550.05-2

550.06 Retrofitting Existing Pavements. Retrofitting with longitudinal edge drains is primarily applicable to pavements showing distress due to excess moisture in the pavement structure.

Retrofitting is not recommended for portland cement concrete pavements exhibiting the following conditions:

- More than 10% of the surface exhibits cracking.
- A high number of transverse joints are spalled.
- Where pumping has occurred (unless the voids under the pavement are to be corrected).
- Localized distress exists such as: edge punchouts, transverse cracking, longitudinal and diagonal cracking, which require extensive patching to return the pavement to an adequate level of service.
- A cement treated base exists which is no longer intact.

Retrofitting is not recommended for any pavement which has unbound base material containing greater than 15% passing the 0.075 mm (No. 200) sieve.

Fine grained subgrade materials may not benefit from edge drains unless the base is drainable.

550.07 Retrofitting Drainage Collection System. The longitudinal edge drain should be placed as close to the edge of pavement as possible. Where cement/lime treated base or subbase extends beyond the edge of the pavement, the edge drain should be located at the outside edge of this layer or trenched through the treated base.

Where the edge drain must be placed outside the treated base, untreated drainage aggregate and a geotextile should be used to provide positive drainage from the edge of the pavement to the edge drain.

The longitudinal edge drain and outlet pipes should be designed as previously recommended for new construction.

550.08 Theoretical Design Method. A theoretical method of designing a drainage system is provided in the Federal Highway Administration Manual "Drainable Pavement Systems" FHWA-SA-92-008 Manual dated March 1992. This detailed method may be needed when a stabilized permeable base is used. A brief synopsis of this design method is as follows:

The design inflow rate is calculated by the crack infiltration equation.

$$qi = Ic\,[Nc/W + Wc/(W \times Cs)] + kp$$

Where:

qi = Infiltration rate (m^3/day/m^2) or (ft^3/day/ft^2)

Ic = Crack infiltration rate (m^3/day/m) of crack or (ft^3/day/ft.) of crack

Nc = Number of longitudinal cracks & joints

Wc = Length of contributing transverse crack or joint (m) or (ft.)

Cs = Spacing of contributing transverse cracks or joints (m) or (ft.)

W = Width of proposed permeable layer (m) or (ft.)

kp = Pavement coefficient of permeability ($m^3/day/m^2$) or ($ft^2/day/ft^2$)

It is recommended that a rate of Ic = 0.223 $m^3/day/m$ (2.4 $ft^3/day/ft.$) be used for most design applications. However, if values of Ic by local observation of infiltration and pavement performance are available, then these values should be used. Additionally, for new pavement kp is essentially 0.

Secondly, the discharge of the permeable base can be calculated by Darcy's equation.

$Q = KiA$

Where:

Q = Flow capacity of the base (m^3/day) or (ft^3/day)

K = Coefficient of permeability (m/day) or (ft./day)

i = Slope of hydraulic gradient (m/m) or (ft./ft.)

A = Cross sectional areas of flow (m^2) or (ft^2)

NOTE: The thickness of the permeable base may be established by the time to drain analysis presented in FHWA-SA-92-008.

Lastly, the pipe flow can be calculated by the equation

$Qp = qiLW$

Where:

Qp = Pipe flow (m^3/day) or (ft^3/day)

qi = Infiltration rate ($m^3/day/m^2$) or ($ft^3/day/ft^2$)

L = Outlet spacing (m) or (ft.)

W = Width of permeable base (m) or (ft.)